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U. S. DEPARTMENT OF AGRICULTURE.

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Experiment Station Work,

XXXIV.

Compiled from the Publications of the Agricultural Experiment Stations.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

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EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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ILLUSTRATION.

EXPERIMENT STATION WORK.[a]

AMERICAN-GROWN SUGAR-BEET SEED.[b]

It is estimated that the production of sugar from sugar beets in this country could be increased at least 2 per cent by the exercise of the same care in the production of seed as in European sugar-beet-growing countries. This would mean a total annual increase in sugar production in the United States of over 50,000 tons.

American sugar-beet growers have heretofore relied almost exclusively upon seed imported from France and Germany, but experience has shown that while excellent seeds are undoubtedly grown in large quantity in those countries, American growers should not for various reasons rely upon those sources of supply. Discussing this subject, J. E. W. Tracy, of the Bureau of Plant Industry of this Department, says:

> It is absolutely essential to success that we secure the best quality of seed, and past experience has conclusively shown that we can not depend upon doing so from abroad. We must raise it ourselves, and in such a careful, scientific manner that it will not only be of the best quality, but will have such characteristics as will make it adapted to the particular needs and requirements of the locality where it is to be sown. Seed raised on a particular soil and under certain climatic conditions may not be best suited for planting in like soils and under similar climatic conditions; in fact, very often it is not. Seed from comparatively poor soil may do best on rich soil, or that raised in the East may do best when sown in the West. Only study and personal experience on the part of each factory manager can determine what seed is best suited for the conditions in his region.

Tests of American-grown seed in comparison with the best imported seeds procurable made by this Department have shown that seed grown by American seedsmen who had little knowledge and made little use of the scientific methods practiced in Germany produced beets which compared very favorably in sugar content, purity, and

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Montana Sta. Rpt. 1904, p. 233; U. S. Dept. Agr., Yearbook 1904, p. 341; Rpt. 74, p. 153; Rpt. 80, p. 177.

yield with beets produced by imported seeds. These results encourage the belief that with the application of more strictly scientific methods home-grown seeds much superior to the imported and better suited to local conditions can be grown in America.

This Department, realizing the importance of these facts to the beet-sugar industry of the United States, "has undertaken to assist in the establishment of a pedigreed strain of sugar-beet seed and to determine the environmental influences of the different sections upon this strain." This work has been taken up in cooperation with several of the State experiment stations, including those of New York (State), Michigan, and Utah, and with private parties.

The work was begun by securing the best strains of European seed and also all known strains of American-grown seed and growing them for comparison. Of these the best four strains were selected as foundation stocks, and all beets of exceptional quality were saved and planted the next spring as mother beets for seed production. In 1904 one-half of the seed secured from these individual plants was planted and the best specimens of beets preserved for the production of the first crop of élite seed. The other half of the seed was saved for planting in 1905, and from the beets produced the next year's supply of élite seed will be grown.

It is reported that during 1904 a Washington State sugar-beet seed grower produced a lot of some 300 roots testing 21 per cent or more of sugar in the beet, with composite tests showing coefficients of purity ranging from 86 to 91.9. In this lot were included 15 roots containing 24 per cent, 50 with 23 per cent, and 100 with 22 per cent of sugar in the beet. Results of variety tests of sugar-beet seed from American and European growers in 1904 show a range of from 15 to 17.7 per cent of sugar in the beet, and a range in coefficient of purity from 83.7 to 87.9. The low as well as the high figures were secured in Kleinwanzlebener sugar beet from American-grown seed. The highest yield per acre, 13.17 tons, was obtained from Kleinwanzlebener seed grown at Fairfield, Wash.

In 1904 this Department distributed some 4,000 pounds of California-grown and 11,000 pounds of Washington-grown Kleinwanzlebener sugar-beet seed, in order to compare it with the seed furnished to farmers by the factories. Of the reports received, 73 per cent of those planting Washington-grown seed and 63 per cent of those planting the California-grown seed found it to be of quicker, stronger, and healthier germination, and none found it inferior to the other seed. The returns from 561 acres showed that the sugar content of the beets from the Washington-grown seed was 15.4 per cent and from the California-grown seed 14.4 per cent, as against 14.9 per cent for beets from the factory seed. The Washing-

ton seed yielded 10.7 tons, the California seed 9 tons, and the factory seed 9.1 tons per acre.

V. K. Chestnut, of the Montana Station, reports cooperative tests with beet growers in which Kleinwanzlebener beet seed produced in the State of Washington, and secured by this Department, was distributed in Montana. Tests of the beets raised showed that the richest lot contained 22.8 per cent of sugar. The largest estimated yield of sugar per acre—5,825 pounds—was obtained on the station farm. Vilmorin Imperial, French Red Top, and Utah sugar beets, grown in comparison with the Washington-grown Kleinwanzlebener seed, were inferior in every particular with the exception that the Utah-grown seed showed a purity 1.08 per cent greater than the Kleinwanzlebener. The average of 22 beets grown in various parts of the State from this seed contained 16.9 per cent of sugar with 82.73 per cent purity.

While the experiments have not been continued long enough to warrant positive conclusions, the results obtained clearly indicate that the home production of pedigreed sugar-beet seeds may be profitably undertaken in the United States.

The methods of growing such seeds are fully described by Mr. Tracy in the Yearbook of this Department for 1904.

STIMULANTS FOR SEEDS.[a]

The possibility of stimulating the germination, especially of old seeds, and promoting the growth of plants by treating the seeds before planting with various substances, has been the subject of a number of studies both abroad and in this country, which have yielded results that promise to be of practical value. It has been repeatedly observed that certain of the treatments used in prevention of smut (for example, use hot water and copper sulphate) apparently stimulate germination and growth and result in a greater increase in yield than can be accounted for simply by the influence of the treatment in preventing disease. G. E. Stone and associates, of the Massachusetts Experiment Station, have shown that such results may be obtained by means of treatment with a variety of chemical solutions as well as by electrical stimulation of the seed. Of the experiments conducted in this country those made by F. A. Waugh, of the Vermont Experiment Station, and later repeated at the Massachusetts Experiment Station, have given results which promise to be of most practical value. Professor Waugh's experiments, which

[a] Compiled from Massachusetts Sta. Bul. 43, Rpts. 1900, p. 74, 1903, p. 13; Vermont Sta. Rpts. 1896–97, p. 106, 1898, p. 290; Country Gent., 71 (1906), No. 2764, p. 66.

were begun as long ago as 1896, were based upon the assumption that the transformation of the starch in the seed is an essential process in germination, and that the so-called enzyms, such as diastase, which are especially active in bringing about such transformation, would probably aid germination when used in the treatment of the seed. He therefore soaked old and fresh seeds of different kinds in solutions of diastase and similar substances before planting. He found in general that the percentage of germination and the vigor of the young plantlets were increased by such treatment, diastase, either from malt or from various commercial preparations, being especially active in this respect. He found that tomato seeds responded especially well to the action of the diastase.

In his more recent experiments Professor Waugh treated tomato seeds of different ages not only with diastase but with malt extract and with beer, which contain a certain amount of diastase. He found that the germination of old seeds was greatly promoted, and the vigor of the plants was increased by soaking overnight in weak solutions of diastase, or in malt extract or beer. The germination of tomato seeds 5 to 6 years old was increased 600 per cent by the diastase treatment. Similar results, though less marked, were obtained with fresh seeds. In all cases the plants were more vigorous, and apparently more resistant to disease (damping off). The results in general indicate that this method of treatment may be profitably employed if a cheaper source of diastase than that now available can be secured.

The results obtained in these experiments confirm those by Jensen in experiments made in Sweden with oats and barley. He found that treatment of seed grain with a weak extract of malt gave an increase in the yields obtained at harvest time in comparison with seed treated with water only, showing that the extract produced an increased vegetative energy.

Similar results are reported by Bréal and Giustiniani, of France, with, however, a very different method of treatment, as follows: The seed was placed in a solution containing from one to five parts per thousand of copper sulphate, in which was stirred while boiling 2 to 3 per cent of starch. After cooling the mixture, four to five times its weight of seed was placed in it, thoroughly mixed, and allowed to remain for twenty hours, after which the seed was dusted with lime and spread to dry. This method of treatment increased the yield of all the crops experimented with, including corn, wheat, barley, oats, lupines, and buckwheat.

These various experiments encourage the hope that some of these methods may eventually be profitably applied in practice in certain cases, especially in the stimulation of old seeds and others of low

vitality. Many important details, however, remain to be worked out before any of the methods proposed can be recommended for general or extended use.

PROFITS FROM SPRAYING POTATOES.[a]

The profitableness of thorough spraying to protect potatoes against fungus diseases and insect enemies was very strikingly shown in experiments reported by F. C. Stewart and associates, of the New York State Station. The experiments have been made under the direct supervision of the station or in cooperation with growers in different parts of the State. In general thorough spraying with Bordeaux mixture was very effective against blight, rot, and flea-beetle.

While in a few cases all loss from these causes could not be prevented even by thorough spraying, in every case where there was a severe outbreak of blight enough good was done to repay all expenditure, both of money and of time. Generally, spraying was very profitable. Of those whose tests were reported to the station, thirty growers made a net profit of $10,000 from spraying.

In fourteen cooperative experiments, covering 180 acres, made in 1904, the average increase in yield due to spraying was 62¼ bushels per acre, the cost of spraying was $4.98 per acre, the cost per acre for each spraying, 93 cents, and the net profit per acre $24.86. Similar and almost equally profitable results were obtained in six experiments made in 1903.

Not only were there gains in yield due mainly "to lengthening the time of growth by preventing foliage destruction by late blight," but the sprayed potatoes, being more mature, were of better cooking quality.

Chemical analysis showed about one-sixteenth more dry matter in the sprayed potatoes and one-ninth more starch. Cooking tests confirmed the analyses, as the sprayed potatoes were noticeably more mealy than those not sprayed, and were pronounced of much better quality by all who ate both. * * *

The mixture recommended by the station is Bordeaux of the 1-to-8 formula; that is, 6 pounds of copper sulphate to 50 gallons of water, the acid of the sulphate being neutralized by about 4 pounds of good stone lime. * * * Paris green may be safely added to thoroughly neutralized Bordeaux [mixture and] this combination—Bordeaux and an arsenical poison—has given better results in station tests than any other fungicide-insecticide treatment for potato pests. * * *

If thorough spraying is the object, it would be best to begin when the plants are 6 or 7 inches high and to spray every ten days or two weeks thereafter as long as the plants remain green. If rain comes before any application is dry on the vines the treatment should be repeated, but spraying should not be stopped because "it looks like rain."

[In the experiments reported] the number of applications ranged from three to ten, and these were made with apparatus varying in power and efficiency all the way from a 5-gallon compressed-air sprayer carried by the operator to a

[a] Compiled from New York State Sta. Bul. 264.

power sprayer treating six rows at a time and covering 15 acres in a day. There was no fixed relation between make or type of sprayer and efficiency of protection. Some home-made outfits gave excellent results. The essential feature is a good pump or other source of power, so that a fine spray can be secured; all other factors are incidental. * * *

If only three applications are to be made during the season, delay the first until it is necessary to treat the potatoes for the potato-beetle "slugs," or shortly before the middle of July in central and western New York. Then use the Bordeaux and arsenicals and spray thoroughly. The second and third applications should also be thoroughly made and at such times as will keep the vines as well coated as possible with the Bordeaux. * * * It is not safe to depend on resistant varieties and neglect spraying. There is no good commercial variety, so far known, that is "blight proof," and claims to that effect may be discounted at once. Some varieties are more resistant than others, and these should be selected, other things being equal, but even these should be sprayed.

In order to secure general spraying at the most economical rates the station suggests that growers arrange for a "public sprayer."

That is, let some one man in the neighborhood make a business of spraying and secure enough fields to keep him busy throughout the season. This plan combines several advantages: The farmer need not learn how to spray; one outfit will do for a considerable area; the materials can be bought in large quantities and therefore more economically; the professional sprayer will become expert and do the work better and faster than the grower himself; and the farmer will be relieved of all extra work connected with spraying. In short, the public sprayer could spray potatoes cheaper and easier than the farmer can do it himself and make good wages at the same time.

TREATMENT OF WINTER-INJURED FRUIT TREES.[a]

Recently attention was called to some of the causes of winter injuries to fruit trees.[b] A number of means of preventing winter injury, either wholly or in part, were there suggested as the result of observations at the different experiment stations.

When, however, the injury has been done, the next step is to find out how such winter-injured trees should be treated. H. J. Eustace, of the New York State Experiment Station, has recently reported the results of experiments along this line. The winter of 1903–4 was unusually cold and long in New York, and resulted in great injury to all kinds of orchard fruits throughout the State. Fruit growers in the different sections were anxious to know how to distinguish between trees that were fatally injured by cold and those that might be expected to recover. It was supposed by some at first that the amount of discoloration of the wood of the tree would indicate the extent of the winter injury, but this was found not to hold true, as

[a] Compiled from Michigan Sta. Buls. 177 and 187; New York State Sta. Bul. 269; U. S. Dept. Agr., Bureau of Plant Industry, Bul. 51, pt. 3; Missouri Sta. Bul. 55; Mass. Sta. Rpt. 1905.

[b] U. S. Dept. Agr., Farmers' Bul. 227, p. 12.

was pointed out by M. B. Waite in Bureau of Plant Industry Bulletin 51, part 3. In one instance, peach trees which were located in a low hollow or "pocket" were examined in March. Below the snow line the wood was sound and of normal color, but above this line the bark, though tight on all portions of the tree, was very dark brown all through and the trunk wood was black. On the limbs the bark and wood were discolored as high up as a man could reach. These trees completely recovered and made a good growth of new wood during the season, though none of the trees bore fruit. The next season every tree was in good condition and bore a good crop of fruit.

In another orchard many pear trees 2 to 5 years old were examined. The wood and bark of these trees were badly discolored, and the common opinion was that the trees in which the bark was badly discolored were practically ruined, and that the best way would be to cut them off below the snow line and let them send up sprouts from the stumps. These young trees, however, with but few exceptions made good healthy foliage and a good wood growth during the season, and by the next season had made a very good recovery.

In another orchard of old peach trees the bark on the trunk of many trees could be easily peeled from the wood and these trees were thought to be dead beyond any question by all who examined them. For the most part, however, they produced a good crop of healthy, large-sized, well-colored foliage and made a very fair recovery.

In another instance a Keiffer pear orchard was found in which the bark and heartwood were discolored black all through and the trees were thought to be certainly dead, yet they produced a fair crop of fruit the same season, though somewhat undersized, and by the next June were all in splendid condition, the foliage being of good size and color. A good new growth had been made and a large amount of fruit set.

Similar observations were made in a Bartlett pear orchard in which the trees were about 15 years old. A number of sweet cherry trees, which, when examined, showed various degrees of discoloration in the bark and wood, recovered from the injury. Japanese plum trees, which, when examined in March, were thought to be dead, ripened a fair crop of fruit during the season and when examined in September had made a thick layer of new wood and bark.

All these observations indicate that it is extremely difficult to tell by any ordinary observation the real condition of trees at the end of the winter season and their ability to overcome the winter injury.

A number of experiments were made to determine what effects different methods of pruning might have on the recovery of the trees. In some instances the young trees were cut off below the snow line and

the old trees were cut back to the large limbs or "dehorned." Other trees were given a moderate pruning, and some were not pruned at all.

When peach or pear trees 7 to 8 years old or over were cut back to where the limbs were about an inch and a half to two inches in diameter or "dehorned," they failed to recover and by the following September all were dead. On the other hand, young peach trees 2 to 5 years old thus treated made a splendid recovery, and trees thus pruned back in January made a better growth than when the cutting back was deferred until March. Young trees in the same

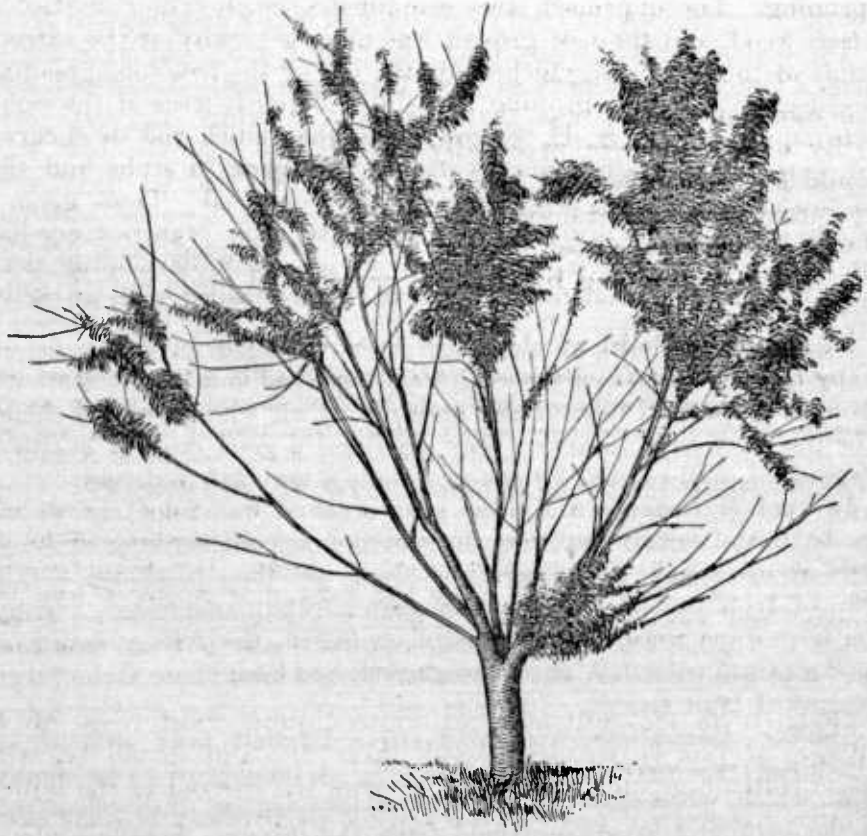

FIG. 1.—Poor growth of peach tree which was not pruned after severe winter injury.

orchard not pruned at all either died outright or the new growth was mostly in the top, making an undesirable tree (fig. 1). One of the objections to pruning young peach trees back so severely is that it induces a too great growth of new wood which forms a bushy top and necessitates a good deal of additional pruning. The results of these experiments "indicate that the winter-injured trees of over 7 or 8 years are killed by 'dehorning,' while younger trees may be treated in that way and expected to make a good recovery."

In orchards of both old and young peach trees a moderate amount of pruning back was compared with no pruning and with "dehorning." The trees moderately pruned made in every instance a much better growth than those not pruned at all. Old trees which died when "dehorned" recovered when only moderately pruned.

Much the larger number of the injured trees were not pruned at all, and while many of these made a recovery which was satisfactory to the grower, it was evident that the average condition of these trees was not nearly as good as when they were given a moderate pruning. The unpruned trees contained a much larger amount of dead wood, and the new growth was more generally at the extreme ends of the branches, which made the top of the tree too spreading.

In experiments in pruning frost-injured peach trees at the South Haven substation, S. H. Fulton states that much risk is incurred in cutting the main branches of the tree back to stubs and that a moderately severe pruning is highly beneficial. Trees given a moderately severe pruning or cutting back on branches one-half to three-fourths inch in diameter grew vigorously, developing clean, new, thrifty tops, and for the most part were loaded with attractive fruit of fine quality.

On the other hand, trees which were pruned lightly after the usual plan of heading in and thinning out part of the new growth have grown more slowly, were marked by smaller, less thrifty foliage, bore fruit of smaller size and poorer quality, and this fall contain much more dead wood. But it must be admitted that no manner of pruning will entirely renovate a badly frozen tree. There is hardly a tree above 4 years old on the station grounds that is not rotten in trunk and main branches and is held together only by the new growth which has been made since the freeze. This being the case, the trees broke down badly in winds and under their weight of fruit this season. But trees well cut back, having made a greater development of new wood, were better able to resist influences which tended to break them down, and doubtless their lives will be considerably prolonged.

Relative to the cultivation of winter-injured fruit trees, M. B. Waite, of this Department, states that "the aim should be, with good cultivation and fertilization, to grow the tree out of the injury. Stable manure will probably answer the requirement in some cases. Nitrate of soda at the rate of 200 pounds per acre may be preferable in other cases. The choice of the writer would be a complete fertilizer, consisting of nitrate of soda, acid phosphate or bone meal, and muriate of potash. Such a fertilizer applied just at the time growth is starting would result in the best possible benefit from the nitrate."

Mr. Eustace further reports the results of observations on 8-year-old peach trees which had been sprayed in the fall with different kinds of sulphur washes. These sprays killed all the fruit buds but the trees made a vigorous growth during the season. On the other hand, unsprayed trees which blossomed dropped all their fruit and

deteriorated rapidly, many of the trees dying during the season, and it is believed that many thousand bearing peach trees in western New York orchards which died during the summer might have been saved had the crop of fruit, or part of it, been removed early in the season.

F. A. Waugh, of the Massachusetts Station, also reports the results of experiments in pruning back peach trees injured by cold during the winter of 1903–4. Some trees were left unpruned; some were headed back near to the trunks leaving only stubs of the main branches; some were "dehorned," that is, cut back to the trunk; and on others only two-thirds to three-fourths of the previous season's growth was pruned back. These moderately pruned trees made the best growth during the following season. Ninety-nine per cent of the trees thus treated lived, while only 93 per cent of the unpruned trees lived, 81 per cent of those severely cut back, and 52 per cent of those dehorned.

J. C. Whitten, of the Missouri Station, also reports the results of extensive experiments in pruning back frozen peach trees in 1902. As the result of his investigations he found that 1-year-old trees cut back nearly to the original bud made the best growth, while the best growth of 2-year-old trees was obtained when they were cut so as to leave the trunk and spurs of the main branches. Young bearing trees cut back to 2-year-old wood and to 3 or 4 year old wood in older trees, leaving stubs of limbs 3 to 4 feet long, gave the best results. Judgment is required not to leave too much wood, which gives a weak growth and high heads, and not to cut back so far into the dormant wood that buds will fail to start.

The results of all these observations indicate that it is exceedingly difficult to tell in the early spring the exact condition of fruit trees as regards the extent of the winter injury, and that it is the part of wisdom to moderately prune the orchard and give it an opportunity to grow at least one season before the trees are finally removed. The trees are aided in their recovery by thorough cultivation and an application of some good fertilizer.

DURUM WHEAT FOR MACARONI AND BREAD MAKING.[a]

Durum or macaroni wheats are now widely recognized as important and useful crops for many regions in the United States in which other varieties of wheat have not proved satisfactory.[b] There are many varieties of durum wheat which differ in yield and the character and quality of the grain. Some of them are most excellent for

[a] Compiled from South Dakota Sta. Buls. 82, 92; U. S. Dept. Agr., Bureau of Plant Industry, Bul. 70.

[b] For previous article on this subject see U. S. Dept. Agr., Farmers' Bul. 186, p. 6.

macaroni making and for grinding into flour, while others are inferior. This variation, which is by no means confined to this class of wheat, undoubtedly accounts for the conflicting statements which have been made regarding the baking quality and other characteristics of durum-wheat flour.

The South Dakota Experiment Station, cooperating with the Bureau of Plant Industry, has devoted much attention to studying the value of different varieties of durum wheat for macaroni making and for milling and has made many tests of the quality of American macaroni and of the bread and other foods made from durum flour.

The color, texture, and cooking quality of macaroni may be judged, according to J. H. Shepard, who has carried on the South Dakota work, by boiling a sample briskly for fifteen minutes in salted water and noting the appearance and flavor.

> A good macaroni will be white in color and retain its shape. When eaten it will be tender and have a slightly sweetish taste, together with a peculiar nutty flavor, which is characteristic. A poor macaroni will have a starchy, unpleasant taste, and the flavor will be disagreeable. It may also be tough and leathery. If it has soured in curing the disagreeable flavor will betray the fact.

In Professor Shepard's studies of the milling and baking qualities of durum wheats a large number of samples of Northern or Russian, Southern or Mediterranean, and miscellaneous durum wheats were examined, as well as of some standard varieties of bread wheats included for purposes of comparison. The milling tests showed that although some of the durum wheats were of inferior quality, yet on an average this class of wheats compared favorably with the standard bread wheats. Of the different varieties of durum wheats the best results were, as a rule, obtained with a specimen of Kubanka. This yielded a greater percentage of flour than any of the others studied, which in color did not differ from the best Blue Stem wheat flour. According to Professor Shepard, the Russian durum wheats, as a whole, gave better results than the others, although there were wide differences among the samples milled.

Color tests of the flour showed a considerable range in the different samples, the durum wheats comparing favorably with the standard wheats on an average. In general, the color of flour depends directly upon the fineness of grinding and this, Professor Shepard believes, accounts for some of the differences of opinion regarding the color of durum flour.

A study of the bread-making qualities of the various wheats showed that the quality of the durum flour was largely dependent upon the variety of wheat selected, some of the samples producing bread which was considered to be equal or superior to that made from the best bread wheat, while others yielded bread of very poor quality.

In other words, when durum wheats are grown for flour making, suitable varieties should be selected. Of those tested the Kubanka gave a better loaf than any of the other samples studied.

The food value of wheats is, of course, determined largely by the content of protein and the proportion of this protein which passes into the flour. If wheat is used for stock feeding it does not matter very much where the protein is located, whether in the bran or in the shorts, the total amount present being the criterion; but, as Professor Shepard points out, it is evident that the best wheat for milling is one which gives the largest percentage of protein in the flour rather than in the bran and other by-products, and that the most economical wheat to grow and mill is the one which yields the largest percentage of total protein in the flour.

As regards the distribution of protein it was found that on an average the bread wheats studied contained 14 per cent, of which the flour contained 9 per cent, the bran 3 per cent, and the shorts 2 per cent. The durum wheats tested contained on an average 16 per cent total protein, distributed as follows: Nine per cent in the flour, 3 per cent in the bran, and 4 per cent in the shorts. The Kubanka wheat, which was regarded as the best of the durum wheats for bread making, contained on an average 15 per cent protein in the whole wheat, of which 10 per cent was found in the flour, 2 per cent in the bran, and 3 per cent in the shorts.

The nitrogenous constituents (protein) of wheat and flour are commonly known as gluten. This gluten is made up of two main constituents, glutenin and gliadin, and the bread-making value of a flour is determined mainly by the relative proportions of the gliadin and the glutenin in the gluten. The larger the proportion of gliadin the larger and better the loaf. A satisfactory flour for bread-making purposes, it is stated, should contain from 55 to 65 per cent of its total gluten in the form of gliadin. The percentage of gliadin in a number of samples of durum flours examined ranged from 45 per cent with Yellow Gharnovka to 59 per cent with Kubanka. The proportion found in Blue Stem Minnesota wheat was 67 per cent. Judged by this standard some of the durum flours were satisfactory, while others were not.

From studies of the proportion of wheat gluten present in the different flours and the results of sponge tests, it appeared that the bread wheats were slightly superior, pound for pound, but that the greater quantity of gluten in the durum-wheat flours offset this advantage. The sponge test used is considered by the author as a more accurate measure of the tenacity of gluten than the loaf volume, owing to the greater accuracy obtainable in measuring the dimensions and rise of the sample, and thus judged the durum wheats compared favorably with the standard varieties.

From a summary of data on the effect of soil and climate on the total protein of durum wheats the conclusion was reached that these factors have not induced any general deterioration in protein content. In other words, that the imported seed produces as good wheat in America as in its native country. The protein content, of course, varies more or less in different seasons. The author does not believe that varieties of durum wheat having a low gliadin content and poor baking quality can be improved by cultivation. These should be let alone, and the good durum wheat grown.

The demand at present is for a durum wheat that will make good macaroni, an attractive flour, and a bread that is satisfactory in loaf, color, and flavor. It is realized that this is much to ask of one variety of wheat, but the belief is expressed that the problem is capable of a satisfactory solution.

The key to success lies in choosing only the best kind or kinds for cultivation. After that the best localities for growing this best kind to perfection must be carefully determined. It is now well known that the macaroni wheats are preeminently dry-weather wheats. This leads to the inevitable conclusion that the drier parts of our country are the natural habitats of these new wheats, and it is to those localities we must look for our supply of the highest grade of macaroni wheat.

In a recent publication of the Bureau of Plant Industry, M. A. Carleton and J. S. Chamberlain summarize data regarding the character and uses of durum flour for macaroni making, etc., and studies are reported of the composition and baking quality of durum and other flours.

The total proteid content of durum wheat flour from wheat grown in Russia and from that grown in this country in normal seasons is considerably higher than that in any of the other principal classes of American wheat. In durum wheat grown in the United States in wet and otherwise unfavorable years the proteid content falls to an amount about equal to that of northwestern hard spring wheats or Kansas hard winter wheats, but is above that of the soft winter wheats. On the average the proteid content of durum wheat flour grown in 1902 or 1903 is equal to that of northwestern hard spring wheat of the same year, but in flour made from normal wheat grown under more favorable conditions it is higher.

The amount of gliadin plus glutenin in the flours from the typical wheats studied is in practically the same relation as the total proteids just described.

The absorption and expansion are, as a rule, greater in the case of flour from durum wheat than of flour from hard spring wheat or hard winter wheat.

The ash content of durum wheat patent flour is considerably higher than that of hard spring wheat patent flour.

In general, durum wheat flour differs in composition from hard spring wheat flour in having larger amounts of proteids, ash, and sugar; but in unfavorable seasons, having too much moisture, some of these fall to about the same amount as found in the other hard wheats.

When durum flour was compared with ordinary flour on a commercial scale in a large bakery, the results indicated that the durum

flour was satisfactory and that the two sorts of flour were very similar. From this and other bakery tests the conclusion was reached that durum wheat on an average makes as good bread as the average hard spring and hard winter wheat flours. The fact that durum wheat flour is satisfactory for making biscuits, cakes, and other foods is spoken of. This flour is often more or less yellow in color. When this is the case it obviously could not be used for cakes which are desired to be quite white. Its possible use for the manufacture of cereal breakfast foods is also mentioned.

A bread-making test under laboratory conditions, in which durum wheat flour was compared with spring wheat flour, led the authors to conclude that—

Durum wheat flour produces a bread that, as a rule, contains slightly more moisture and loses this moisture at a slower rate than bread made from hard spring wheat flour.

The average weight of loaves of equal loaf volume is slightly greater in the case of durum wheat flour than of flour from hard spring wheat. The average loaf volume of loaves scaled to the same weight when molded is almost the same with the two kinds of flour.

Durum wheat flour and the bread from it contain noticeably larger amounts of sugar than hard spring wheat flour or bread.

The ash content of durum wheat flour and bread is greater than that of hard spring wheat flour or bread.

The value of the two kinds of bread, as measured by the heat of combustion, is practically the same.

FERTILITY OF EGGS.[a]

Data regarding the factors which affect the fertility of eggs are of great importance in the poultry industry, and this question has been studied at a number of the experiment stations in the United States and elsewhere.

Too warm quarters for laying stock and overfeeding are commonly believed to exercise an unfavorable influence on egg fertility, as is also a cold season. The way eggs are handled or stored is also believed to affect the proportion which will hatch, as are the conditions under which incubation occurs. The vigor and character of the parent stock and the length of time the male bird has been with the flock are also important questions with respect to egg fertility. At the outset it should be pointed out that fertility and "hatchability" are not necessarily identical. An egg may be fertile but the germ may not have sufficient vitality to produce a healthy chick under the ordinary conditions of incubation. In a series of incubator experiments at the Rhode Island Station, of 8,677 eggs tested 83 per cent

[a] Compiled from Canada Expt. Farm Rpts. 1903, p. 239; Maine Sta. Bul. 93; Ontario Agr. Col. and Expt. Farm Rpt. 1898, p. 195; Rhode Island Sta. Rpts. 1902, p. 333, 1903, p. 269; Utah Sta. Bul. 51; Agr. Student, 1 (1894), No. 1, p. 6.

were found to be fertile, while only 46 per cent of the fertile eggs, or 38.6 per cent of the total number of eggs, hatched under the conditions of the tests, although under ideal conditions a greater hatch would doubtless have been obtained.

Experiments reported by G. M. Gowell at the Maine Experiment Station showed that there was as great variation in the fertility as in the total egg yield of different hens, some producing eggs that were all highly fertile and others eggs that were completely infertile, and, furthermore, that eggs of some individuals varied greatly in this respect at different times. The observed facts did not indicate that a heavy egg yield was a hindrance to fertility, provided the hens were allowed to rest after a laying period before they began to lay again. Although in general it seemed that infertility is likely to result after hens have been laying long and heavily, it was not found that this was always the case. In this connection it should be noted that the vigor of the male bird is also an important question.

The effect of the presence of the male bird on egg fertility was studied at the Ohio State University with 40 Leghorn hens, which had previously been kept without males. They were placed in pens with three male birds February 18 and the percentage of fertile eggs observed for nine days after mating. This increased regularly from 0 on the day of mating to 95 per cent on the eighth day after mating. July 1 the males were removed from the pens. "The fertility of the eggs was apparently not materially affected until the twelfth day after removing the roosters. * * * Unfortunately the eggs were saved only fifteen days, and hence it is not shown how long hens must be removed from the male before all the eggs become infertile."

This point was also studied at the Ontario Agricultural College and Experimental Farm. The hens were separated from the male and the eggs laid each day were placed in an incubator and tested with respect to their fertility. Of the eggs laid during the first four days after the male was removed 70 per cent were fertile; of those laid on the fifth day, 61 per cent; on the sixth, 60 per cent; on the seventh, 49 per cent; on the eighth, 12 per cent; on the ninth, 2 per cent, and on the tenth all were infertile.

A test was also made with six laying hens to determine the time which must elapse before eggs become fertile after a male is introduced. On the third day 30 per cent of the eggs were found to be fertile; on the fourth, 42 per cent; on the fifth, 50 per cent; on the sixth, 60 per cent; on the seventh, 70 per cent; on the eighth, 68 per cent; on the ninth, 70 per cent; on the tenth, 74 per cent.

The influence of the male on the total number of eggs produced was also tested with two lots. Lot 1 consisted of 5 pullets, 5 hens, and 1 cock; lot 2, of 5 hens and 5 pullets of the same varieties as lot 1. The

test began January 1 and lasted until September 1. Both pens were fed and cared for in the same way. Lot 1 laid 959 eggs and lot 2 laid 972 eggs. "It can be seen that there was but very little difference in the number of eggs laid by the two pens."

In tests made at the Rhode Island Station the low percentage of efficiency in incubating eggs in winter has been ascribed to the conditions of the winter egg and the hen—that is to say, it is claimed that the winter embryos have less vitality than spring embryos. The experiments reported, however, showed that while no entire lot of hatches was especially good for any month, there were some in all months that were good, in fact much better than the average for any month, which was an indication that the methods of incubation tested were at greater fault than the eggs and that the observed differences in the proportion of eggs hatched could not be attributed to the season in which the eggs were laid.

A. G. Gilbert, the poultry manager of the Canada experimental farms, found that generous and gently stimulating rations given to fowls kept in cold poultry houses did not seem to affect the strength of the germs of the eggs laid by them, though similar rations apparently affected the eggs of hens kept in artificially warmed quarters. Eggs laid in early December by hens in artificially warmed houses showed a greater percentage of strong germs than was the case with eggs laid later in the season. Eggs laid by the same hens in early spring showed a satisfactory percentage of fertility, but the weakest germs. "The most striking and gratifying results were obtained from the fowls which, like their parent stock, had never known warm quarters. From 55 eggs laid by these fowls in early spring—after laying well during the winter—48 strong chickens were hatched. In contrast with this are 17 chickens from 52 eggs laid by hens kept in warmed but comparatively limited quarters." The results as a whole were strongly in favor of the average farm conditions of feeding and housing as regards the production of eggs with strong germs.

The influence of cold and heat and some other conditions were studied with reference to the hatching of eggs in a series of tests published by the French minister of agriculture.[a] It was found that fowls hatch larger and stronger broods during the months of February, March, and April than during the warm months of June, July, and August. It was also found that the eggs of fowls which were at liberty hatched better than those of fowls which were confined. It was found, in tests made with an incubator, that eggs which were repeatedly cooled and warmed hatched much better than those which were kept at a warm temperature all the time. In one experiment the eggs were cooled by exposing them to the air for 1.5 hours daily dur-

[a] Dairy, 8 (1896), p. 61.

ing the whole period of incubation. This treatment retarded the period of incubation for three days. The eggs became quite cold, and it required about twelve hours to bring them up to 104° F., the temperature of incubation. Of 16 eggs thus treated, 13 hatched vigorous chickens. The incubator had previously been used with unsatisfactory results.

From a second experiment it was inferred that the gradual heating of the eggs was as essential as the process of cooling. Twenty-five eggs which had been laid on very warm days were placed in the incubator and exposed to air as in the preceding case. The temperature was such that the eggs were warmed up to 104° in two or three hours. This temperature was maintained until the brood hatched. The chickens pierced the shell, but they were so weak that they died before leaving the egg.

It was found that the eggs upon which a fowl is sitting are not all of the same temperature, those upon the outside being cooler than those which lie inside.

As regards the effect of extreme temperature, a French investigator [a] who studied the influence of freezing on the development of the embryo in hens' eggs found that low temperature produced marked changes in the embryo and that when the eggs hatched monstrosities were numerous.

The relative fertility of old, medium, and fresh eggs of chickens with and without exercise was studied by J. Dryden at the Utah Station. Exercise apparently reduced the fertility of the eggs. The observed percentage of fertility was highest with eggs from early hatched pullets and lowest with eggs from old hens, but the results are not regarded as conclusive. The fertility of the eggs averaging 5 days old was found to be 300 per cent greater than that of eggs averaging 22 days old.

These various observations, while not entirely conclusive, indicate that, in order to secure fertile eggs which will hatch, the laying stock must not be kept in very warm quarters or overfed, the males must be kept with the hens continuously and only eggs produced after the male has been with the hens several days used, only fowls from very vigorous parent stock and those known to produce a high percentage of fertile eggs (hens vary widely in this respect) must be used, the hens should be allowed a rest after each laying period, the eggs should be handled carefully and not subjected to extremes of temperature in storage, and the eggs should be used when comparatively fresh.

The experience of practical poultry raisers indicates that an exclusive grain ration should not be fed, but that meat should be given several times a week, that the males should be well fed and kept

[a] Compt. Rend. Acad. Sci. [Paris], 128 (1899), p. 1183.

healthy and vigorous, and that a certain amount of exercise is necessary for both hens and males.

In general it may be said that the ordinary conditions prevailing on the farm as a rule favor the production of eggs of high vitality.

The keeping quality of eggs is a very different matter from fertility. It is the general belief that infertile eggs keep better than fertile.

INDOOR VERSUS OUTDOOR FEEDING FOR FATTENING STEERS.[a]

The question of the economy of indoor versus outdoor feeding for fattening steers in a climate such as that of central Pennsylvania has been studied by the Pennsylvania Experiment Station, among others, for several years. In a recent bulletin of this station T. I. Mairs and N. G. Miller report experiments on this subject carried on during the winter of 1904–5, and summarize the work of previous experiments along the same line. In these experiments 24 grade steers containing Galloway, Shorthorn, Hereford, or Aberdeen Angus blood, divided into two lots of 12 each, were used, one lot being fed in a pen in the basement of the college barn and the other in an open shed in a yard adjoining the barn. The two lots were fed alike on a ration of ear corn, corn stover, and clover hay. The four main points on which observations were made were: (1) The comparative gain in live weight; (2) health and vigor of the animals as indicated by appetite and general appearance; (3) the relative economy of the two methods as far as relates to amount of feed consumed per pound of gain; and (4) relation of gain to temperature of surroundings.

The results obtained in experiments made during three years are summarized in the following table:

Summary of results of three years' experiments in feeding steers in the barn and in open sheds.

	Barn.	Open shed.
Daily gain per steer ..... pounds..	1.94	1.82
Hay fed for a pound of gain ..... do....	3.29	3.45
Stover fed for a pound of gain ..... do....	3.32	3.47
Grain fed for a pound of gain ..... do....	8.86	9.08
Estimated cost of feed per pound of gain ..... cents..	10.66	11.26
Difference in favor of barn-fed steers ..... do....	.60	.....

The results show in general that the steers fed in the open ate less total food than those fed in the barn, but slightly more per pound of gain, thus making the cost of feed per pound of gain somewhat greater for the open-fed than for the barn-fed lot. The differences are, however, so slight that it is safe to conclude that the gains made by fattening steers are not increased by warm quarters, and that it is

[a] Compiled from Illinois Sta. Circ. 98; Kansas Sta. Buls. 34, 39; Minnesota Sta. Bul. 76; Pennsylvania Sta. Bul. 74.

not possible to have stables too cold for fattening steers in this climate, provided they are kept dry and well bedded. It is necessary, however, in order to get the best results in outdoor feeding to keep the yards from becoming excessively muddy and to keep the sheds dry. This may be done by good drainage and the use of soft-coal cinders in the yards, and by supplying plenty of bedding and removing the manure from the sheds sufficiently often. By these means the sheds "can be kept practically as dry as the interior of the barn."

The relative value of barns and sheds has been tested at other stations. Thus, at the Kansas Station, it was found that the steers running in yards made larger gains on the whole than those tied in stables, but required about 12 per cent more grain for a given amount of increase.

At the Minnesota Station the question of shelter was one of the points studied in a series of feeding experiments. A lot fed indoors made an average daily gain of 1.74 pounds as compared with 2.26 pounds in the case of the lot fed in sheds, the cost of a pound of gain in the two cases being 6.47 cents and 5.61 cents, respectively—that is to say, the gain was greater and more cheaply made when the steers were fed in open sheds than when fed in stables; but Professor Shaw, who carried on the experiment, considered that additional tests should be made before definite conclusions could be drawn.

At the Missouri Experiment Station, H. J. Waters[a] made a series of tests extending over several years to determine the effect of shelter on the gains made by steers fed heavy rations of corn and hay in the winter. In every case the most satisfactory gains were made by the animals which had the least shelter. The average daily gain of the steers fed in barns was 1.7 pounds per head; of those fed in sheds, 1.92 pounds, and of those fed in open yards, 2.05 pounds, the amount of feed required per pound of gain being 14.79, 14.12, and 14.22 pounds, respectively.

> It is needless to say that we were not prepared for quite this outcome. While we were fully convinced that cattle of this class accustomed to outdoor life could be easily overhoused when on full feed of such heating and fattening foods as corn and timothy hay, especially after they had laid on considerable fat, it was reasonable to suppose that a more economical gain and even more rapid gain would be obtained when they were sheltered against the storms. While the difference between the gains of the bunches in the open shed and the open lot do not indicate a large advantage in favor of the open shed, yet from every point of view it seems fair to say that where much winter feeding is to be done it will be profitable to provide suitable shelter for the cattle, the feed, and the manure, and particularly to give the cattle a dry place on which to lie. From these experiments it does not appear to be necessary or profitable to attempt to make such quarters warm.

[a] Mo. Bd. Agr. Mo. Bul., 1 (1901), No. 6, pp. 14–26; Ann. Rpt. Mo. Bd. Agr., 35 (1903), p. 264.

To secure additional information on this point letters were sent out to a large number of cattle feeders in Missouri and adjacent States. Of the 1,300 who replied 17.6 per cent favored feeding in closed barns, 59.2 per cent in open sheds, and 23.2 per cent in open lots. The experience of practical feeders, therefore, seems to be in accord with the results of the experiments cited. As Professor Waters points out, it should be remembered that these statements apply to cattle on full feed, and not to young, thin animals or to breeding cattle.

That different results may be expected with such cattle is shown by tests carried on at the Missouri Station for four years with yearlings. One winter the animals were fed on hay only, and for three winters on a small quantity of corn and what timothy hay they would eat. On an average the young steers fed in the barn were in much the best condition and had the better coat, etc. "It would be the same way with any other class of cattle if due care is taken not to overhouse and to keep their quarters well ventilated."

The Illinois Experiment Station made a special effort to obtain data from a large number of feeders with a view to deducing some general principles regarding various questions of cattle feeding, and over 500 replies were received. One of the questions concerned the kind and amount of shelter necessary for fattening cattle. One-half of the correspondents stated that sheds were used; about one-third, principally those who fed in spring and summer, used pens, lots, or open fields, but usually gave the cattle access to shade or shelter of one sort or another; about 10 per cent fed in barns; a smaller number depend on woods and straw stacks for shelter, while only two individuals stated that they practiced stall feeding. The percentage of those who fed without sheds was greater among Iowa and Nebraska correspondents than among those in Illinois.

With regard to the possibilities of securing better results, providing the steers had access to closed sheds or warm barns, two-thirds of the correspondents believed that such protection would be advantageous, many making the qualification that the barn or shed should be well ventilated and lighted and that the steers must not be confined too closely.

In a discussion of the question of barns *v.* sheds, H. R. Smith,[a] of the Nebraska Experiment Station, draws attention to the fact that there is danger in overhousing cattle as well as in underhousing. "Cattle are not likely to be uncomfortable, even during cold weather, so long as they are protected from cold winds and have a dry bed. The latter is more necessary than is ordinarily supposed, and a roof is no doubt worth more than its cost for this purpose. It would seem

[a] Profitable Stock Feeding, by H. R. Smith. Lincoln, Nebr.: Author, 1906, p. 145.

that, in the Northern States especially, some sort of a shed open on the side opposite prevailing winds is most satisfactory for fattening cattle."

It is evident from the data which have been summarized that the results of different investigators have not been entirely uniform, some having found barns slightly more advantageous than sheds and others the reverse. It seems fair to conclude that skillful feeders have obtained satisfactory results by both methods, and that, in general, profitable stock feeding depends more upon other questions of feeding and management than upon the kind and amount of shelter provided.

When very large numbers of cattle are fattened it is evident that the comparative cost of housing in barns and sheds must be taken into account and that sheds would be much the cheaper.

ROUGHAGE FOR FATTENING STEERS.[a]

Realizing that in view of present prices for both corn and beef the character of the roughage fed in connection with corn in the fattening of range steers is a factor of greater importance than has heretofore been realized by cattle feeders, the Nebraska Station has for some time past been conducting a series of experiments to determine the relative value for this purpose of the more common rough feeds available for use in that region. The experiments were made with both yearling and 2-year-old steers. In the latter case 50 range 2-year-old steers, mostly grade Shorthorns, known in the stock yards as "hay feds," were fed in 5 separate and uniform lots of 10 each. The rations compared were (1) shelled corn and prairie hay; (2) shelled corn 90 per cent, oil meal 10 per cent, and prairie hay; (3) shelled corn and alfalfa hay; (4) shelled corn, alfalfa hay, and corn stover; and (5) shelled corn 90 per cent, oil meal 10 per cent, and sorghum hay. The experiment extended from January 21 to July 8, 1905, there being a preliminary period of twenty-four days in which the animals were gradually accustomed to the experimental rations. The animals had access to shelter at will. The only respect in which these experiments with 2-year-old animals differed from earlier experiments with yearlings was the use of alfalfa hay as a source of protein in the place of oil meal for the steers fed corn stover.

The results show that alfalfa hay was decidedly superior to prairie hay for beef production. It is therefore of great importance to extend as rapidly as possible the area of land devoted to the production of alfalfa, supplanting the less valuable and lower yielding native hay. The superiority of the alfalfa over prairie hay was especially marked when the grain ration consisted of corn alone. "It also

[a] Compiled from Nebraska Sta. Buls. 85, 90.

proved to be a cheaper source of protein than oil meal. The returns on the cattle fed alfalfa hay, were the alfalfa figured at $11.14 per ton, would have been as great as the returns on prairie hay at $6 per ton, with corn as the grain ration at 39 cents per bushel. In comparison with prairie hay at $6, when oil meal worth $28 per ton was a part of the grain ration, the alfalfa returned a value of $8.28 per ton."

If for any reason native prairie hay is the most available roughage for feeding purposes it should not be fed with corn alone, but with corn supplemented with a small quantity of some highly nitrogenous feed, such as oil meal, which is rich in protein, to give a more evenly balanced ration.

In these experiments the addition of oil meal did not lessen the cost of production of a pound of gain, but it did result in a better finish, which caused the animals to sell for 15 cents more per hundred, making a profit of $1.09 per head where a loss of $1.13 resulted from feeding corn and prairie hay only.

The results of the experiments further indicate that cornstalks, cut and put in the shock immediately after the ears ripen, possess a food value which the feeder can not afford to ignore. Existing land values warrant the larger utilization of this kind of rough feed by the adoption of methods of harvesting that will make such material more available for feeding purposes.

Bright, well-cured corn stover, fed with an equal weight of alfalfa, the grain consisting of corn alone, gave slightly larger gains than corn and alfalfa, and proved the most economical ration in the experiment. The addition of corn stover may have improved to some extent the corn and alfalfa ration by furnishing greater variety, and by its tendency to check scours sometimes caused by alfalfa. The stover fed with alfalfa returned a value of $4.57 per ton, in comparison with alfalfa at $6 per ton as the sole roughness.

Sorghum hay did not give as good results as prairie hay.

The margin between cost and average selling price (net) for all steers in this experiment was a little less than $1 per hundred. While the profit was small, the steers returned a good price for the rough feeds at the market values quoted—high enough to make them profitable crops to grow on the farm. Had the feeds been sold, these values for roughage would not have been secured on the average Nebraska farm, nor would the manure have been left to make the next crop larger. The results furnish a strong argument in favor of judicious feeding.

CHEAPENING THE DAIRY RATION.[a]

In an earlier number of this series[b] the economy of substituting home-grown feeds rich in protein for purchased feeds was discussed upon the basis of experiments conducted by C. B. Lane at the New

[a] Compiled from Maryland Sta. Bul. 98; New Jersey Stas. Buls. 174 and 190; Tennessee Sta. Buls. Vols. XV, No. 4, XVII, No. 4.

[b] U. S. Dept. Agr., Farmers' Bul. 202, p. 22.

Jersey Station, and in a later number,[a] Ohio station work, by C. G. Williams, was referred to as showing that corn silage may replace with profit a large part of the grain ration usually fed to dairy cows. Additional investigations of a similar nature are here briefly noted with a view to emphasizing again the economy of the fullest possible utilization of home-grown products in feeding, especially of those products rich in protein, such as alfalfa, clover, cowpeas, and other leguminous crops.

At the New Jersey Station three experiments, similar in nature to the earlier work cited, were conducted by C. B. Lane to study the substitution of alfalfa hay, cowpea hay, and soy bean silage for purchased feeds. Each experiment was made with four cows and covered two periods of fifteen days each, the third experiment being duplicated.

In the first experiment a ration consisting of 17 pounds of cowpea hay and 36 pounds of corn silage was compared with a ration made up of 5 pounds of cornstalks, 36 pounds of corn silage, 4 pounds of wheat bran, 3 pounds of dried brewers' grains, and 2 pounds of cotton-seed meal. The cowpea hay ration contained 3.06 pounds of protein and had an estimated nutritive ratio of 1:6. The feed ration contained 3.20 pounds of protein and had an estimated nutritive ratio of 1:5. The cowpea hay ration was produced entirely on the farm, while over two-thirds of the protein of the feed ration was purchased. On the cowpea hay ration the daily yield averaged 23.7 pounds of milk, containing 3.86 per cent of fat; on the feed ration it was 25.7 pounds of milk, containing 4.11 per cent of fat. The feed ration produced 8.3 per cent more milk, or 15.2 per cent more butter, than the cowpea hay ration. At market prices for feeding stuffs the cost of producing 100 pounds of milk was 39.8 cents, and of producing 1 pound of butter 8.82 cents, when the cowpea hay ration was fed. When, however, the feed ration was given, the cost of production was 60.5 cents per hundred for milk and 12.6 cents per pound for butter. With milk at $1 per hundred, these results were interpreted as showing an increased profit for a herd of thirty cows of $37.20 per month from the home-grown ration over the feed ration. "However, it is believed that a combination of coarse and fine feeds is necessary to produce the best results."

In the second experiment the home-grown ration consisted of 36 pounds of soy bean silage, 8 pounds of alfalfa hay, and 6 pounds of corn meal. The protein content of the ration was 3.64 pounds, and the estimated nutritive ratio was 1:5. The feed ration consisted of 6 pounds of cornstalks, 36 pounds of corn silage, 4 pounds of wheat bran, 4 pounds of dried brewers' grains, and 2 pounds of cotton-seed meal. The protein content was 3.45 pounds and the estimated nutri-

[a] U. S. Dept. Agr., Farmers' Bul. 222, p. 31.

tive ratio was 1:6. The average daily yield of milk per cow was 27.2 pounds, testing 3.6 per cent of fat on the home-grown ration, and 25.7 pounds testing 3.8 per cent of fat on the purchased ration. The home-grown ration produced, therefore, 5.81 per cent more milk than the purchased ration. The butter production was practically the same on both rations. On the home-grown ration the food cost of 100 pounds of milk was 56.5 cents, and of 1 pound of butter 13.5 cents, and on the purchased ration 65 and 14.6 cents, respectively, showing a considerable saving when home-grown feeding stuffs were used.

The third experiment showed that when protein was supplied in the form of cotton-seed meal rather than wheat bran and dried brewers' grains, the saving in cost of production was 11.9 cents per 100 pounds of milk and 3.3 cents per pound of butter.

In still later work at the New Jersey Station, G. A. Billings compared a ration consisting of 14 pounds of alfalfa hay, 35 pounds of corn silage, and 2.5 pounds of cotton-seed meal with a ration made up of 40 pounds of corn silage, 7 pounds of cornstalks, 4.5 pounds of wheat bran, 4.5 pounds of dried brewers' grains, and 2 pounds of cotton-seed meal. The experiment was made with 8 cows and lasted sixty days. The results showed that the purchased-feed ration produced 3.7 per cent more milk and 7.2 per cent more butter than the alfalfa-hay ration, but that the cost was much greater. With alfalfa hay and corn silage valued at the cost of production and other feeding stuffs at market prices, the cost of producing 100 pounds of milk on the alfalfa ration was 47.6 cents and on the feed ration 71.8 cents, and the cost of producing 1 pound of butter 10.17 and 14.86 cents, respectively, showing a much greater profit from a home-grown ration. The profit in feeding the alfalfa ration over the purchased-feed ration was estimated at 33.7 per cent for milk and 31.5 per cent for butter. These results were averaged with those obtained in the earlier experiments at the station, the results showing an average saving in cost of production by using home-grown feeds of 22.4 per cent for milk and 20.2 per cent for butter.

At the Maryland Station C. F. Doane compared leguminous crops and commercial feeding stuffs as sources of protein in a number of experiments.

In a test with fifteen cows a balanced ration of alfalfa hay and corn meal produced more milk than a balanced ration of corn silage and mixed grains. In another test with three cows a balanced ration of alfalfa hay and corn silage without grain did not give as satisfactory results, judged from the yield of milk, as a ration of corn silage and mixed grains, indicating that apparently some concentrated feed was necessary for a maximum yield. In several tests with the entire herd during two winters, cowpea silage was compared with corn silage,

the results being interpreted as proving the superiority of the cowpea silage. These results show that alfalfa and cowpeas, in addition to enriching the soil, may be grown for the purpose of supplying to a very large extent the protein in rations for cows.

At the Tennessee Station A. M. Soule and S. E. Barnes showed several years ago that cowpea hay could be substituted with profit for a part of the cotton-seed meal or wheat bran commonly fed to cows. They have more recently conducted similar experiments with alfalfa hay.

Twelve cows were divided into three lots and fed experimentally for four months. Lot 1 consumed 21,376 pounds of corn silage, 3,624 pounds of wheat bran, and 1,207 pounds of cotton-seed meal and produced 7,521 pounds of milk and 439.05 pounds of butter fat. Lot 2 consumed 20,558 pounds of corn silage, 3,638 pounds of alfalfa hay, and 1,871 pounds of cotton-seed meal and produced 7,689 pounds of milk and 424.89 pounds of butter fat. Lot 3 consumed 16,139 pounds of corn silage, 3,350 pounds of alfalfa hay, and 3,725 pounds of wheat bran and produced 6,414 pounds of milk and 347.99 pounds of butter fat. The three rations contained, respectively, 5,792.19, 6,040.21, and 5,986.07 pounds of digestible matter, and had nutritive ratios of 1:4.5, 1:4.2, and 1:5.6. The net cost of producing a gallon of milk was 7.1 cents for lot 1, 5.7 cents for lot 2, and 8.2 cents for lot 3, allowance being made in each case for cost of food and attendance and for the value of the manure. The net cost of producing a pound of butter was 12.3, 10.4, and 15.3 cents, respectively, for the three lots. The best results from an economic standpoint were apparently obtained by lot 2, where wheat bran was replaced by alfalfa hay.

The conclusion was drawn from these results that 3 pounds of alfalfa hay could be made to replace 1 pound of cotton-seed meal, and 1.5 pounds of alfalfa hay 1 pound of wheat bran, the limit of substitution depending upon the individual capacity of the animals to consume hay, but ordinarily not exceeding 10 to 12 pounds of alfalfa hay when fed with silage, nor 15 to 20 pounds when fed without silage. It was evidently better to substitute the alfalfa hay for the wheat bran than for the cotton-seed meal. With alfalfa hay at $10 per ton and wheat bran at $20 per ton the saving effected by substituting alfalfa hay for wheat bran was estimated at 19.8 cents per 100 pounds of milk and $2.80 per 100 pounds of butter.

A comparison of the results of the present with those of the earlier experiments referred to showed that when cowpea hay was fed under the most favorable conditions a gallon of milk cost 5.2 cents, and a pound of butter 9.4 cents, and that when alfalfa hay was fed under the most favorable conditions the cost of a gallon of milk was 5.7 cents, and a pound of butter 10.4 cents. These results show, there-

fore, that either crop may be utilized to replace wheat bran in rations for dairy cows, the choice of the crop depending largely upon its suitability to the locality.

COTTON-SEED MEAL AS FEED FOR HOGS.[a]

Great interest attaches to cotton-seed meal, especially in the Southern States—where this product is to be obtained most cheaply—on account of its high feeding value. As most feeders know, it serves to balance rations with corn, Kafir corn, or other carbonaceous products. Cotton-seed meal has been fed extensively to cattle, hogs, horses, and mules, and in a smaller measure to sheep and chickens. For all of these animals it has a high feeding value, as shown by its effectiveness in producing gains.

The only drawback incurred in feeding cotton-seed meal is the harmful or poisonous effects which it may have at times, especially on hogs. Cotton-seed meal has been shown to be practically harmless for steers when fed in rations not to exceed 4 to 6 pounds per day for the usual length of the feeding period. It may be fed to dairy cows in rations of 5 to 6 pounds indefinitely without causing any injurious effects and with good influence upon the milk yield. Horses and mules may be fed cotton-seed meal in rations of 2 to 4 pounds per day without danger, and sheep in rations of one-half pound.

The most serious results from feeding cotton-seed meal have occurred with hogs, and this has led to extensive investigations regarding the nature of the poisonous substance, the effect upon the animals, and the means of preventing this poisonous action. In these investigations several experiment stations have taken part, notably those in Arkansas, Oklahoma, Alabama, North Carolina, and Iowa. Thus far the poisonous substance in cotton-seed meal has not been identified. According to recent experiments by Dinwiddie in Arkansas, it appears not to be the oil which may be present in the meal nor any substance which may be readily removed in an aqueous broth obtained from the meal. On account of the difficulty thus encountered in determining the nature of the poisonous substance, attention has been chiefly directed to the determination of the amounts of cotton-seed meal which may be safely fed to pigs of different weights. In Alabama pigs were fed as high as 4½ pounds of crushed cotton seed per day, but all lost weight or showed signs of illness. In Iowa death or serious illness took place in hogs weighing 100 pounds before they had eaten more than 30 pounds of the cotton-seed meal. In North Carolina no bad results were obtained from feeding 1¼ pounds of the meal

[a] Compiled from Alabama College Sta. Bul. 68; Arkansas Sta. Buls. 31, 76, 85; Iowa Sta. Buls. 28, 32, 66; Kansas Sta. Bul. 53; Mississippi Sta. Bul. 13; North Carolina Sta. Bul. 109; Oklahoma Sta. Buls. 51, 58; Texas Sta. Buls. 41, 78; Washington Sta. Bul. 67.

daily to pigs weighing 90 pounds, but when the amount was increased to 2 pounds a day serious trouble followed.

The most extensive work along this line has been carried out at the Arkansas and Oklahoma experiment stations. In Oklahoma it was found that a safe programme might be devised for feeding pigs on cotton-seed meal by adding it to the ration for alternate periods of two or three weeks. At this station no bad effects from feeding meal to hogs was observed so long as the period during which they received it regularly did not exceed three weeks. In most of the experiments at the Oklahoma Station it was found that small pigs when fed a mixed grain ration, containing one-fifth to one-fourth cotton-seed meal, would die inside of ten weeks. In some instances, however, it was found possible to feed a grain ration, containing from one-tenth to one-fifth cotton-seed meal, for an indefinite period, provided the pigs were allowed to run on green pasture or were fed soiling crops. The Oklahoma Station, therefore, recommends that cotton-seed meal should not constitute more than one-fifth of the grain ration for hogs; that it should be fed in alternate periods of two or three weeks, and that the hogs should also have green food.

From the extensive experiments carried out at the Arkansas Station on this subject, it appears that the harmful effects of overfeeding with cotton-seed meal may appear in any species of animal. Apparently the reason why the results are not serious with dairy cattle and steers is that the amount usually fed to these animals is quite small when compared with their body weight. The good or injurious effects of cotton-seed meal are believed to be determined by the amount fed. Small amounts may be fed for indefinite periods, while large amounts can be given only for short periods without serious results. The poisonous effect of cotton-seed meal is therefore determined by the size of the daily ration rather than by the total amount received for the whole period. From the numerous experiments being carried out at the Arkansas Station, definite recommendations have been formulated regarding the safe daily allowance of cotton-seed meal for hogs of different weight. These recommendations are as follows: For pigs under 50 pounds weight, one-fourth pound per day; 50 to 70 pounds weight, one-third pound per day; 75 to 100 pounds weight, two-fifths pound per day; 100 to 150 pounds weight, one-half pound per day. The amount of cotton-seed meal fed to hogs should also bear a certain ratio to the other components of the grain ration. It is recommended that cotton seed be fed in the proportion of 1 part to 5, 6, 7, or 8 parts, respectively, of the other grain for the four classes of hogs just mentioned, on the basis of weight. In general, wheat bran has been found to be a particularly desirable material to mix with cotton-seed meal, on

account of the fact that it appears to render the whole ration safer than when the meal is mixed with ground corn.

Cotton-seed meal does not exert any noticeably harmful effect on breeding stock when fed according to the recommendations just outlined. Chopped cotton seed may be fed in the same manner and proportion as cotton-seed meal. Cotton-seed hulls appear not to be poisonous for hogs, but this product is not available for hogs except when ground into a sort of bran.

On account of the high feeding value and effectiveness of cotton-seed meal in hog rations, it is of great importance to the farmer to know just how much of the meal may be fed without danger to hogs. It is believed, therefore, that the recommendations made by the Arkansas Station suggesting definite amounts for hogs of certain weights may serve as a valuable guide to farmers in this matter.

Quite recently the Texas Station has studied the effect of fermented cotton-seed meal upon hogs. In these experiments it appeared that cotton-seed meal may be safely used in somewhat larger quantities and for longer periods when fermented and fed in a form of slop. The test was made during the hot summer season, and is believed, therefore, to be a severe one, since the conditions were somewhat unfavorable for the hogs. The injurious effects of the cotton-seed meal were not entirely removed by fermenting, but when fed in small quantities it appeared to be safe to make cotton-seed meal a part of the ration for an indefinite period, especially where some green food was given at the same time.

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